REMARKS/ARGUMENTS

Applicants respectfully submit, contemporaneously herewith, a Request for Continued Examination pursuant to 37 C.F.R. § 1.114.

Claims 1-35 have been cancelled and replaced by a new claim set comprising Claims 36-54.

It is submitted that the revised claims overcome the objections and are in proper form under 35 U.S.C. § 112. The claims now specify what is causing the beat signal, namely, the interference of the object beam and the reference beam both coming out of the frequency shifted feedback laser resonator and interfering on a detector. It has also been clarified that the seed laser is modulated in order to increase the beat signal.

Independent Claims 36 and 47 call for a frequency shifted feedback resonator having a pumped gain medium therein with a gain greater than or equal to unity, means for splitting the emitted laser light into an object beam for irradiating an object and a reference beam and a means for injection of narrow banded, non-pumping, modulated seed laser light into the frequency shifted feedback resonator with the result that the intensity of the beat signal is increased.

As outlined below, the prior art applied by the Examiner fails to render the claimed subject matter obvious to one of ordinary skill in the art.

In the Philips device, a laser radiation source emits frequency shifted light onto an object and laser light radiation is sent to a detector which receives light radiation coming back from the object illuminated as well as a laser light beam. In particular, looking at Fig. 1 of Philips, a laser source 12 designated as "MO" (= master oscillator) laser source is feeding light both into a heterodyne detector 104 and an optical ring circuit 20

> *"... used to produce a wide band light signal having many discrete frequency components 192, 193, 194, ... from a single laser beam used as a seed frequency which is produced by a master oscillator laser source 12. The light signal 35 is then [further] amplified ....."*

(column 7, lines 29-35). For the sake of completeness, it should also be noted that the optical ring circuit has a gain medium and a pump light source providing energy for the gain medium of the optical ring circuit 20. The heterodyne detector first receives light from the master oscillator laser source 12 and the optical ring circuit 20. The output of the heterodyne detector thus is a beat signal between the beam of MO laser source 12 and the output of

optical ring circuit 20. This output is conditioned in a signal processing circuit 198 (column 7, line 54) and then digitized and stored.

The output of the optical ring circuit is sent via a second stage amplifier 40 and a modulator switch to a telescope directing the amplified output of the optical ring circuit 20 onto a target (or, in the words of the present application, onto an "object"), and then receives light back from the target. The light received back from the target is fed to the heterodyne detector 104 which still receives light from the MO laser source and does not receive light directly from the optical ring circuit 20 any longer. The corresponding signal obtained with the light coming back from the target and the MO laser source output at the heterodyne detector is then also conditioned and digitized. Thereafter, it is attempted by <u>numerical correlation techniques</u> to determine <u>the time of flight</u> of the pulsed output of the optical ring circuit to the target and back to the telescope in order to determine the distance of the target.

Therefore, it is important for Philips that the optical ring circuit is not emitting light as a continuous wave (<u>no CW radiation</u>). Rather, the light beam is gated and thus pulsed. It should be noted that there is a CW broad band light signal 35 by the optical ring device 20 as stated in column 8:

> *To create the (CW) broad band light signal 35 .... Finally needed are discrete pulses each pulse consisting of a frequency comb the pulsed waveform is obtained with an optical switch modulator 24 forming part of the optical ring circuit 20.*

Thus, Philips correctly states:

> *The pulsed waveform produced by the optical ring circuit 20 has a wide band width that is rich in frequency content ....*

(column 9, line 7 ff).

This pulsed behavior is significantly different from the present invention where the interference is effected between a reference beam coming out of the FSF-laser itself and the object beam. In the present invention, accordingly, <u>both</u> the <u>reference beam and</u> the <u>object beam have</u> the <u>same frequency behavior</u> In contrast, in Philips there is a <u>continuous wave reference beam</u> not varying in frequency over time <u>and a pulsed object beam</u> having certain frequency components.

Furthermore, it should be noted that the optical ring circuit 20 does not constitute a frequency shifted feedback laser resonator having a pumped gain medium therein. Generally, the term "lasing" or "laser" is used when amplification at round trip is > 1. This requires a certain overall gain. In the present application, the gain curve is shown in Fig. 4 and it is stated that the gain is above 1 for the FSF ring laser. In direct contrast, Philips states that

> *"The overall gain of the optical ring circuit has to be kept slightly below unity to prevent oscillation which would have the undesirable defect of generating excessive band width beyond the detection capability of large dynamic range photo diode suitable for imaging applications."*

Thus, although light of the Philips MO laser source after having passed through the optical ring circuit 20 could be called "laser light which has been frequency shifted by a frequency shifting resonator", it is not light from a "laser resonator having itself a frequency shifted feedback". Thus, what is shown in Philips is not a frequency shifted feedback laser resonator. Rather, it is only a single mode laser having a comb producing, light gating device placed downstream thereof.

Also, it should be noted that no reference at all is made in column 2, line 56, to column 3, line 10, and column 7, lines 29-47 of Philips to a modulation of the seed light, leave alone to varying a modulation frequency around a signature frequency. Although a formula is given in column 2 referring to the Fourier spectrum of an emitted waveform having a given temporal duration, no reference is made for example to any chirp rate. The same holds for column 7, lines 29-47.

Therefore, neither does Philips show a frequency shifted feedback laser (but only laser light shifted by an optical ring device) nor does he suggest to modulate any light from a frequency shifted laser. He also does not suggest to split the output of a frequency shifted feedback laser itself so as to allow for the interference of a measurement beam and a beam from the FSF-laser having a similar frequency component thus allowing for a simple detection of a beat intensity maximum with varying modulation. This has unexpected influence on the behavior of the light beam as will be discussed below. Rather, Philips needs to digitize the beat signal of a single frequency master oscillator and a gated output of a non-lasing optical ring circuit and has to numerically correlate this signal to a similar signal

obtained with the single seed master oscillator beam and a gated frequency comb reflected back from a target.

Furthermore, there are significant differences to Gabl as well.

Gabl also does not disclose a frequency shifted feedback laser resonator. What is shown is a regenerative amplifier resonator cavity into which seed laser pulses are injected. The final output thereof is an output pulse similar to the output in Philips. The average skilled person who would have access to such an output pulse would use it in the same manner as the output pulse obtained by Philips.

Furthermore, it also is an object of Gabl, US 5,592,327,

> *"... to provide improved regenerative amplifier systems which are free of emission due to self-oscillation from the resonant cavity of the amplifier itself."*

Thus, what is not wanted by Gabl is self-oscillation. The regenerative amplifier resonator cavity thus is again not a device lasing on its own.

Then, the resonant cavity of the regenerative amplifier is stated to have a spectral filter within the resonant cavity. It is stated that the resonator cavity can include a spectral filter element which is tunable (column 9, line 2):

> *"..... so that fine adjustment of the central wavelength of oscillation of the output pulses obtainable within the oscillating band width of the injected seed pulse."*

Thus, there is no modulation of the seed pulse but rather a modulation of the resonator. Here, it should also be noted that what is referred to is "tuning" and not modulating.

Therefore, in summary neither Philips nor Gabl discloses a frequency shifted feedback laser having a frequency shifted feedback resonator and a modulated seed laser.

Furthermore, neither Gabl nor Philips suggests to split light outputted from the frequency shifted feedback laser resonator into an object beam and a reference beam. In view of the fact that Philips uses the output of his device for time of flight-measurements by digitizing the heterodyne signal of a master oscillator and the beam comprising the frequency components obtained after the master oscillator beam has passed through the optical comb producing device, even when combining Philips with Gabl, the average skilled person would

have no incentive to bring into interference two beams split up from the same laser output without going through a particular optical device.

Since the average skilled person would have no incentive from these cited references to produce a beat signal of two beams having a similar frequency component behavior, he would also have no incentive to increase the (heterodyne) beat signal intensity of these two beams having a similar behavior, leave alone by modulating any seed laser.

The Examiner´s attention is drawn to the fact that in the meantime a theoretical explanation in line with the present invention co-authored by the present inventor has been published in *OPTICS COMMUNICATIONS*, 281 (2008) 1679-1685. A copy of this document is submitted herewith as Exhibit A. In this article, the variation of amplitude modulation signal with distance is discussed in detail (paragraph 4, page 1682-1683). It should be noted that *OPTICS COMMUNICATIONS* is a highly regarded and reviewed journal and that the publication in this journal itself is evidence of the non-obviousness of the claimed subject matter, even to a scientist, let alone an ordinary skilled person not into academic research.

It is also noted that a further paper titled "*COHERENCE IN THE OUTPUT SPECTRUM OF FREQUENCY SHIFTED FEEDBACK LASERS*" by L. P. Yatsenko, B. W. Shore and K. Bergmann gives a detailed theoretical analysis of the coherence properties of the output form a frequency shifted feedback laser seeded simultaneously by an external seed laser and by spontaneous emission. This is the situation obtained by the device of the present invention. The corresponding paper is submitted herewith as Exhibit B for the Examiner's review.

As can be seen in the "Summary and Conclusions" section, as well as in the abstract, spontaneous emission (SE) and external seed compete in a way that differs from the usual way of exponential growth of modes with greater gain. It is stated that there occurs a balance that is related linearly rather than exponentially to control parameters. The observed behavior is stated to differ from that of a normal laser.

Why should the average skilled person expect a behavior to be different from that of a normal laser when seeding laser light into an FSF laser resonator having spontaneous emission as well? Furthermore, why should the average skilled person obtain any incentive to do so in view of Philips and of Gabl when neither even suggests to use a frequency shifted

feedback laser resonator having sufficient spontaneous emission? Finally, given that the output spectrum of seeded frequency shifted feedback lasers differs from the behavior expected from normal lasers, why should the average skilled person have any incentive to then modulate the seed frequency? How could he anticipate that this gives extra benefits due to the unexpected behavior?

The applied prior art does not teach laser having an FSF laser resonator with a gain medium to allow for lasing while a modulated seed laser is injected. The fact that the output of such a device significantly differs from the output of a non-feedback laser seeded with modulated light is completely unexpected. The results and advantages obtained in this way also would not be expected.

The enclosed paper "*AN INTUITIVE PICTURE OPTIC RANGING USING FREQUENCY SHIFTED FEEDBACK LASERS SEEDED BY A PHASE-MODULATED FIELD*" identified as Exhibit C correctly states that although the use of phase-modulated (non-FSF) light as a source for interferometric measurements had been suggested in the past, there have been drawbacks preventing practical application in view of the necessity to calibrate measurements of intensity (page 6, last paragraph of chapter I). Yet, a detailed analysis of the FSF-laser with modulated seed that shows that in the interferometric case there is occurring a summation of a very large number of frequency components (typically > 104), (page 10, paragraph under equation (25)).

It is stated that the summed amplitude of the components will typically be very small <u>unless</u> there is a <u>resonant condition</u>. Therefore, in the present invention it suffices to determine the modulation frequency at the time when the intensity of the beat signal (=the power) is increasing by several orders of magnitude using the FSF-light for interferometric measurements and thus there is no need for the intensity calibration previously preventing the use of phase-modulated light in interferometric measurements.

In summary, neither Gabl nor Philips discloses a device according to the present invention. The behavior of the device according to the present invention is different from the behavior expected for a normal laser. The behavior of a device according to the present invention allows to overcome the disadvantages obtained with non-FSF-devices in the past.

Therefore, none of the claims is rendered obvious by the cited prior art.

This holds even in view of the further cited prior art.

Goldberg et al. refers to a solid state laser source of tunable narrow band width ultra violet radiation. In order to produce ultra violet light, second (or third or higher) harmonics are generated using non-linear crystals such as Potassium niobate or Lithium borate. The art clearly distinguishes "nonlinear harmonics generation" using nonlinear crystals from "frequency shifting" devices. The document thus is irrelevant to any FSF device. This holds also in combination with other documents. The allegation of the Examiner regarding obviousness of a modification of the Philips and Gabl devices therefore is incorrect. This is particularly true in view of the fact that modulation of the seed laser of an FSF-laser is producing results unexpected and new over normal laser designs.

Palese does not show the use of a frequency shifted feedback device. Palese aims at very high power level pulsed lasers and uses of a distributed series of fiber amplifiers (column 1, lines 9-10). What is suggested is to provide a modelocked (and thus pulsed) laser with a stretcher to separate frequency components contained in the pulse and an array for receiving said separated ("dispersed") frequency components for amplification thereof. After amplification, the output of the fibers is recombined into a single beam. The fact that a plurality of frequency components in a (pulsed) seed light pulse and the further fact that these wavelengths can be spectrally dispersed has nothing to do with modulation and does not render obvious a modulation. Using the dispersion of a broad band light and modulating light is something completely different.

Mocker, US 5,394,238, does also not refer to an FSF laser. Mocker desires to measure windshear ahead of an aircraft. In order to measure the air movement corresponding to the windshear, the Doppler-shift of molecules (or other matter dispersed in the air) can be measured. To do so, it is necessary to measure the offset of the absorption of a molecule moving with the air ahead of the airplane relative to the absorption of a molecule at rest. Absorption measurement require to tune the laser in a very finely controlled manner and to have a very narrow band emission. Thus, the laser is clearly different from a frequency shifted feedback laser having a broad band output.

Also, it should be noted that Mocker Fig. 6 is referred to in column 7, lines 37-63. This paragraph has been cited by the Examiner. However, what is shown in Fig. 6 simply is the timing behavior of pump power, population inversion and so forth. Fig. 6 does **not** disclose anything about wavelength and behavior of the gain medium. In particular, it does

not refer to a wavelength where the gain of the pumped gain medium is unity nor does it relate to a wavelength of the seed light. Since Fig. 6 or the corresponding discussion in column 7, lines 37-63, does not refer to any wavelength, the cited part of the Mocker document does not teach that the seed light has a wavelength close to the wavelength where the gain of the pumped gain medium is unity.

In Shattil, US-PS 5,955,992, there is not disclosed a modulated frequency shifted feedback laser . It is noted that column 6, line 9 refers to a traveling wave FSFC-laser "as described in certain cited papers co-authored by Shattil". ("FSFC" is an abbreviation for **F**requency **S**hifted **F**eedback **C**avity; an FSFC laser thus is the same as an FSF laser in the present application). However, it is also stated (column 6, line 22 ff.) that the optical processor for the antenna array shown in Fig. 1 derives its operational characteristics from a traveling-wave FSFC (Frequency Shifted Feedback Cavity). Then, it is stated that the FSFC 100 ".... may also include a gain medium (not shown)."

However, such a gain medium simply is not optional in a laser, but is absolutely necessary to provide for lasing. No mention is made that IF a gain medium would be included at all, it would have to have a gain sufficient to provide for lasing. Now, Shattil refers to the use of a FSF cavity for an antenna system. It is extremely unlikely that an average skilled person who wishes to provide for an antenna system would allow self-oscillating to happen in a part of the antenna.

Accordingly, what is shown in Shattil is not a frequency shifted feedback laser but a device allegedly

> *"... **having the same broad band characteristics** as the frequency shifted feedback laser described in the aforementioned papers",*

(column 6, line 57 ff.) Therefore, Shattil does not teach any injection laser injecting non-pumping injection laser light into the gain medium of a **frequency shifted feedback laser**. What he does teach instead is to inject laser light into a frequency shifted back cavity which may or may not have a gain medium but is neither stated nor reasonably expected to lase.

In summary, none of the cited documents show an FSF laser having a gain medium with sufficiently high gain in the FSF cavity and a modulated seed laser. Injecting modulated seed laser light into an FSF cavity having sufficient gain to allow for self-lasing will produce unexpected and new results not expected in view of the behavior of a normal, non-FSF laser

or a laser emitting light into a non-lasing FSF cavity. The new and unexpected behavior allows for improved measurements in a simple way not expected by the average skilled person.

In view of the above, it is submitted that Claims 36-54 patentably define over the prior art applied by the Examiner. However, if the Examiner believes that further issues remain, it is requested that he telephone the undersigned at 260-460-1692.

In the event Applicants have overlooked the need for an extension of time, payment of fee, or additional payment of fee, Applicants hereby petition therefor and authorize that any charges be made to Deposit Account No. 02-0385, Baker & Daniels.

Respectfully submitted,

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